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DESCRIPTION

PRECOATED METAL SHEET WITH LITTLE AFFECT ON ENVIRONMENT

Technical Field

5 The present invention relates to a precoated metal sheet using, as the substrate, a metal or plated metal sheet mainly comprising zinc and aluminum. More specifically, the present invention relates to a
10 precoated metal sheet excellent in the coating material adhesion, friendly to the global environment by virtue of not containing hexavalent chromium, which is considered to have a large affect on environment, and suitable for use in automobiles, building materials and home appliances.

15 Background Art

 Many of the metal sheets used for home appliances, building materials and automobiles are precoated for the purpose of enhancing the design properties and corrosion resistance. For such a metal sheet, a chemical
20 conversion treatment, called a chromate treatment, is applied as a pretreatment to coating in many cases, because the chromate-treated film exhibits excellent corrosion resistance owing to the self-repairing function of hexavalent chromium contained in the film and
25 excellent coating material adhesion owing to the hydrous oxide containing hexavalent chromium.

 However, with recent increase in the concern for the global environment, it is required to suppress the elution of hexavalent chromium and, if possible, not to
30 use the chromate treatment.

 Against such a background, a technique called resin chromate obtained by compounding an organic resin and chromate has been reported in JP 5-230666 A. By this technique, the elution of hexavalent chromium can be
35 decreased but cannot be completely prevented.

 On the other hand, various chromate-free treatments having a performance comparable to the chromate treatment

have been recently developed. A representative example thereof is a technique of covering the metal surface with an organic resin having a chelate-forming ability to intensify the bonding force between the cover film and the metal surface. For example, JP 11-29724 A discloses a chromate-free treatment using an aqueous resin containing a thiocarbonyl group-containing compound and a phosphate ion and further containing a water-dispersible silica. However, the coating material adhesion is not necessarily satisfied in uses where severe working is applied.

As described above, a chromate-free treatment with a coating material adhesion at a high level has not been developed and its urgent development is being demanded.

Disclosure of the Invention

Under these circumstances, the present invention has been made and an object of the present invention is to provide a precoated metal sheet excellent in coating material adhesion, free from hexavalent chromium and having little affect on environment.

As a result of intensive investigations to solve the above-described problems, the present inventors have found that when having, on at least one surface of a metal or plated metal sheet mainly comprising zinc and aluminum, a coat layer mainly comprising one or both of a metal oxide and a metal hydroxide each using a metal species exclusive of chromium, a precoated metal sheet exhibits coating material adhesion equal to that of a chromate treated metal sheet and furthermore, that when the coverage of the cover layer is from 50 to less than 100%, the coating material adhesion is equal to or greater than that of the chromate treated metal sheet. The present invention has been accomplished based on these findings.

That is, the gist of the present invention is as follows.

(1) A precoated metal sheet comprising a metal or

plated metal sheet having stacked on at least one surface thereof at least a coat layer and an organic resin layer, the metal or plated metal sheet mainly comprising zinc and aluminum and the coat layer mainly comprising one or both of a metal oxide and a metal hydroxide each using a metal species exclusive of chromium.

(2) The precoated metal sheet as described in (1), wherein the average film thickness of the coat layer is 5 μm or less and the film thickness of the organic resin layer is 1 μm or more.

(3) The precoated metal sheet as described in (1), which comprises, on both surfaces of the metal or plated metal sheet mainly comprising zinc and aluminum, a coat layer having an average film thickness of 5 μm or less and mainly comprising one or both of a metal oxide and a metal hydroxide each using a metal species exclusive of chromium and, on at least one surface, an organic resin layer of 1 μm or more as an upper layer.

(4) The precoated metal sheet as described in any one of (1) to (3), wherein the coverage of the coat layer is from 50% to less than 100%.

(5) The precoated metal sheet as described in any one of (1) to (4), wherein the coat layer is deposited like islands.

(6) The precoated metal sheet as described in any one of (1) to (5), wherein cracks are present in the thickness direction of the coat layer.

(7) The precoated metal sheet as described in any one of (1) to (6), wherein the metal species of one or both of the metal oxide and the metal hydroxide is one or more member selected from zirconium, titanium and silicon.

(8) The precoated metal sheet as described in any one of (1) to (7), wherein the metal species of one or both of the metal oxide and the metal hydroxide is titanium.

According to the present invention, a precoated metal sheet excellent in the coating material adhesion and having little affect on environment can be provided without using a chromate treatment with a chromate
5 containing hexavalent chromium.

Best Mode for Carrying Out the Invention

The present invention will now be described in detail.

The metal or plated metal sheet mainly comprising
10 zinc and aluminum for use in the present invention has, on at least one surface thereof, one or both of a metal oxide and a metal hydroxide each using a metal species exclusive of chromium.

As a result of extensive studies, the present
15 inventors have found that when a coat layer mainly comprising one or both of a metal oxide and a metal hydroxide is present on the surface of a metal or plated metal sheet mainly comprising zinc and aluminum, the coating material adhesion is enhanced as compared with
20 the case of not applying such a treatment at all. The mechanism thereof is not clearly known, but it is considered that this is because the metal oxide or metal hydroxide forms strong chemical bonding with an organic resin coated thereon and this brings about enhancement of
25 the coating material adhesion.

The average thickness of the cover layer mainly comprising one or both of a metal oxide and a metal hydroxide is preferably 5 μm or less. If the average thickness exceeds 5 μm , the coating material adhesion is
30 saturated and this is not profitable or, depending on the case, the performance may decrease. As for the lower limit of the average thickness, even if some portions are not covered, it may suffice if the covered portion is covered with at least a monomolecular layer.

35 The thickness of the organic resin layer stacked on the coat layer is preferably 1 μm or more. If the

thickness is less than 1 μm , the coverage is sometimes insufficient. The upper limit is not particularly limited, but if the thickness exceeds 1 cm, the organic resin layer may fail in exhibiting a satisfactory
5 function or the like.

Also, a coat layer mainly comprising one or both of a metal oxide and a metal hydroxide may be provided on both surfaces of a metal or plated metal sheet mainly comprising zinc and aluminum and then an organic resin
10 layer may be stacked on at least one surface. The coat construction may be appropriately selected according to the purpose.

Furthermore, it has been found that when the coverage of the coat layer mainly comprising one or both
15 of a metal oxide and a metal hydroxide is from 50 to less than 100%, the coating material adhesion is more enhanced and is equal to or greater than that of the chromate treatment. The mechanism thereof is also not clearly known, but an activity analogous to so-called anchor
20 effect is considered to bring about enhancement of the coating material adhesion. The coverage as used herein means a ratio of the cover layer area to the surface area of the metal or plated metal sheet mainly comprising zinc and aluminum. Examples of the objective state include a
25 case where the coat layer is deposited like islands as often seen at the treatment with a low amount of film material, a case where a crack reaching the substrate is present in the coat despite a sufficiently large amount of film material, and a case where cracks are present in
30 the island-like deposition part. If the coverage is less than 50%, the effect by the chemical bonding is insufficient.

The metal species of the metal oxide or metal hydroxide formed on the metal sheet of the present
35 invention is not particularly limited, but examples thereof include iron, magnesium, niobium, tantalum, aluminum, nickel, cobalt, titanium, zirconium and

silicon. This cover layer may be constituted by one metal species or may be a composite, mixture or laminate of two or more metal species. Among these metals, preferred are titanium, zirconium and silicon. It is
5 believed that this is because the oxide or hydroxide of titanium, zirconium or silicon forms good bonding with an organic material. In particular, titanium is considered to form the best bonding.

The method of forming one or both of a metal oxide
10 and a metal hydroxide on the metal sheet is not particularly limited and a commonly known method can be used. Examples thereof include a liquid phase method such as a liquid phase deposition process using a fluoride ion, e.g., fluoro-complex ion of metal, or a
15 sol-gel process, and a dry method such as sputtering or CVD.

The method for controlling the coverage of the metal oxide or metal hydroxide formed on the metal sheet surface or forming cracks is not particularly limited,
20 but examples thereof may include, for example, mechanical grinding with abrasive paper or the like, heat shock such as quenching, and chemical etching with an acidic aqueous solution, an alkaline aqueous solution or a fluoride ion-containing aqueous solution. Of course, cracks may be
25 naturally generated depending on the film formation method or film formation conditions.

Examples of the metal or plated metal sheet which can be used in the present invention is not particularly limited as long as it mainly comprises zinc and aluminum,
30 but examples thereof include JIS 7000 series (Al-Zn type), Zn-Al alloy-plated steel sheet, Zn-Al-Mg alloy-plated steel sheet, Zn-Al-Mg-Si alloy-plated steel sheet and Al-Zn-Si alloy-plated steel sheet.

The coating material for forming the organic resin
35 layer of the precoated metal sheet of the present invention is not particularly limited and a coating material usually used for precoated metal sheets can be

used as-is. As for the resin, commonly known resins may be used according to usage. More specifically, examples thereof include those where a resin component such as high molecular polyester-based resin, polyester-based resin, acryl-based resin, epoxy-based resin, urethane-based resin, fluorine-based resin, silicon polyester-based resin, vinyl chloride-based resin, polyolefin-based resin, butyral-based resin, polycarbonate-based resin, phenol-based resin or a modified resin thereof is crosslinked by a crosslinking agent component such as butylated melamine, methylated melamine, butyl methyl-mixed melamine, urea resin, isocyanate or a mixture thereof, and also include electron beam-curable resins and ultraviolet-curable resins. The coating material for the precoated metal sheet of the present invention may contain a coloring pigment or dye or a gloss-adjusting agent such as silica and also, if desired, may contain a surface smoothing agent, an ultraviolet absorbent, a hindered amine-based photostabilizer, a viscosity adjusting agent, a curing catalyst, a pigment dispersant, a pigment precipitation inhibitor, a color separation inhibitor and the like. Of course, the coating may comprise two or more layers. The undercoat coating may contain a rust-preventive pigment. For the rust-preventive pigment, known rust-preventive pigments can be used and examples of the rust-preventive pigment which can be used include phosphoric acid-based rust-preventive pigments such as zinc phosphate, iron phosphate, aluminum phosphate and zinc phosphite, molybdic acid-based rust-preventive pigments such as calcium molybdate, aluminum molybdate and barium molybdate, vanadium-based rust-preventive pigments such as vanadium oxide, silicate-based pigments such as calcium silicate, chromate-based rust-preventive pigments such as strontium chromate, zinc chromate, calcium chromate, potassium chromate and barium chromate, fine particulate silicas such as water-dispersed silica and fumed silica, and ferroalloys such

as ferrosilicon. These may be used individually or as a mixture of multiple species. Furthermore, a carbon black powder or the like may also be added. However, in order to reduce the affect on environment, use of a chromate-based rust-preventive pigment is preferably avoided.

Examples

The present invention will now be described in greater detail below by referring to Examples, but the present invention is not limited to these Examples.

The metal sheets used were a hot-dip 55% Al-43.4% Zn-1.6% Si alloy-plated steel sheet (plating coverage on both surfaces: 150 g/m²), a Zn-11% Al-3% Mg-0.2% Si alloy-plated steel sheet (plating coverage on both surfaces: 120 g/m²) and an aluminum alloy sheet (7001 (Al-Zn-Mg type)). These metal sheets all had a thickness of 0.8 mm. Each metal sheet sample was subjected to an alkali degreasing treatment (with "SURFCLEANER 155", produced by Nippon Paint Co., Ltd.) and then to the tests.

For imparting a metal oxide or a metal hydroxide to the metal sheet, a liquid phase deposition process or a sputtering process was used.

The treating solutions used in the liquid phase deposition process were the following aqueous hexafluoro-complex salt solutions which were adjusted, mainly using ammonium fluoride and if desired, further using hydrofluoric acid or aqueous ammonia, such that the molar ratio of metal and entire fluorine was about 1:7 and the pH was about 3. That is, these were an aqueous 0.1 mol/L ammonium hexafluorosilicate solution, an aqueous 0.1 mol/L ammonium hexafluorotitanate solution, an aqueous 0.1 mol/L ammonium hexafluorozirconate solution, a mixed aqueous solution of an aqueous 0.05 mol/L ammonium hexafluorotitanate solution and an aqueous 0.05 mol/L ammonium hexafluorosilicate solution (Mixed Solution A), a mixed aqueous solution of an aqueous 0.05 mol/L ammonium hexafluorotitanate solution and an aqueous 0.05 mol/L ammonium hexafluorozirconate solution (Mixed

Solution B), a mixed aqueous solution of an aqueous 0.05 mol/L ammonium hexafluorozirconate solution and an aqueous 0.05 mol/L ammonium hexafluorosilicate solution (Mixed Solution C), and a mixed aqueous solution of an aqueous 0.03 mol/L ammonium hexafluorotitanate solution, an aqueous 0.03 mol/L ammonium hexafluorosilicate solution and an aqueous 0.03 mol/L ammonium hexafluorozirconate solution (Mixed Solution D). Each metal sheet after degreasing was dipped in the treating solution and treated under the following conditions to form a film of metal oxide or metal hydroxide.

(a) Film formation of metal oxide or metal hydroxide by simple dipping

The film formation was performed at room temperature for 1 to 10 minutes and after the film formation, the metal sheet was washed with water and dried.

(b) Film formation of metal oxide or metal hydroxide by cathodic electrolysis using platinum as the counter electrode

The film formation was performed at room temperature for 1 to 10 minutes by controlling the current density to 100 mA/cm² and, after the film formation, the metal sheet was washed with water and dried.

In the sputtering process, a film of a metal oxide was formed on the substrate metal sheet by using Si, Ti or Zr as a target.

Each film formed by the liquid phase process or sputtering process was subjected to analyses by X-ray photoelectric spectroscopy and infrared ray spectroscopy to confirm the production of metal oxide or metal hydroxide. Also, the coverage of the film formed was determined as follows. The film was observed through a scanning electron microscope at a magnification of 10,000 times and after distinguishing the substrate metal and the film by image processing, the ratio of the film was determined. This operation was performed at 5 locations and the average thereof was used as the coverage.

For the purpose of comparison, a coating-type chromate treating agent (resin-containing type) was coated to a metal sheet to give a chromate coverage of 20 mg/m² and then dried.

5 On each of the metal sheet having formed thereon a metal oxide or metal hydroxide film, the chromate-treated metal sheet and the untreated metal sheet, a high molecular polyester-based coating material (NSC200HQ, produced by Nippon Fine Coatings K.K.) was coated to give
10 a dry film thickness of 15 µm, thereby producing precoated metal sheets.

 These precoated metal sheets were evaluated regarding coating material adhesion under the following conditions.

15 The precoated metal sheet produced by the above-described method was dipped in boiling water for 60 minutes. Thereafter, crosscuts were formed thereon according to the crosscut test method described in JIS K 5400 and further an Erichsen process yielding an Erichsen
20 value of 7 mm was applied. A pressure-sensitive adhesive tape (cellophane tape produced by Nichiban Co., Ltd.) was laminated on the worked part and then swiftly peeled off by pulling it toward the oblique direction of 45°, and the number of peeled crosscuts out of 100 crosscuts was
25 counted. The adhesion was evaluated on a 7-stage scale according to the degree of peeling. The scores of the coating material adhesion are as follows.

Score

- 7: No peeling.
- 6: The peeled area ratio was less than 5%.
- 5: The peeled area ratio was from 5% to less than 10%.
- 4: The peeled area ratio was from 10% to less than 20%.
- 3: The peeled area ratio was from 20% to less than 50%.
- 2: The peeled area ratio was from 50% to less than 70%.
- 1: The peeled area ratio was 70% or more.

The results obtained are shown in Tables 1 to 3.

Table 1: Examples of substrate metal sheets of 55% Al-43.4% Zn-1.6% Si alloy-plated steel sheet

No.	Treating Solution (liquid phase process) or Target (sputtering process)	Treating Method	Coverage, %	State of Coat	Film Thickness, μm	Adhesion	Remarks
1	ammonium hexafluorosilicate	simple dipping	100	-	5	5	Invention
2	ammonium hexafluorosilicate	cathodic electrolysis	100	-	5	5	Invention
3	ammonium hexafluorotitanate	simple dipping	40	island-like	3	3	Invention
4	ammonium hexafluorotitanate	simple dipping	50	island-like	3.3	6	Invention
5	ammonium hexafluorotitanate	simple dipping	60	island-like, cracks	3.6	6	Invention
6	ammonium hexafluorotitanate	simple dipping	70	island-like, cracks	4	6	Invention
7	ammonium hexafluorotitanate	simple dipping	80	cracks	4.3	6	Invention
8	ammonium hexafluorotitanate	simple dipping	90	cracks	4.6	6	Invention
9	ammonium hexafluorotitanate	simple dipping	100	-	5	5	Invention
10	ammonium hexafluorotitanate	cathodic electrolysis	100	-	5	5	Invention
11	ammonium hexafluorozirconate	simple dipping	100	-	5	5	Invention
12	ammonium hexafluorozirconate	cathodic electrolysis	100	-	5	5	Invention
13	Mixed Solution A	simple dipping	100	-	5	5	Invention
14	Mixed Solution A	cathodic electrolysis	40	island-like	3	3	Invention
15	Mixed Solution A	cathodic electrolysis	50	island-like	3.3	5	Invention
16	Mixed Solution A	cathodic electrolysis	60	island-like, cracks	3.6	5	Invention
17	Mixed Solution A	cathodic electrolysis	70	island-like, cracks	4	6	Invention
18	Mixed Solution A	cathodic electrolysis	80	cracks	4.3	6	Invention
19	Mixed Solution A	cathodic electrolysis	90	cracks	4.6	5	Invention
20	Mixed Solution A	cathodic electrolysis	100	-	5	5	Invention
21	Mixed Solution B	simple dipping	100	-	5	5	Invention
22	Mixed Solution B	cathodic electrolysis	100	-	5	5	Invention
23	Mixed Solution C	simple dipping	100	-	5	5	Invention
24	Mixed Solution C	cathodic electrolysis	100	-	5	5	Invention
25	Mixed Solution D	simple dipping	100	-	5	5	Invention
26	Mixed Solution D	cathodic electrolysis	100	-	5	5	Invention
27	Si	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
28	Si	sputtering	100	-	5	5	Invention
29	Ti	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
30	Ti	sputtering	100	-	5	5	Invention
31	Zr	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
32	Zr	sputtering	100	-	5	5	Invention
33	chromate treating agent	coating	-	-	-	5	Comparative
34	untreated	-	-	-	-	1	Comparative

1) The film was formed by sputtering and then polished with a diamond paste.

Table 2: Examples of substrate metal sheets of Zn-11% Al-3% Mg-0.2% Si alloy-plated steel sheet

No.	Treating Solution (liquid phase process) or Target (sputtering process)	Treating Method	Coverage, %	State of Coat	Film Thickness, μm	Adhesion	Remarks
35	ammonium hexafluorosilicate	simple dipping	100	-	5	5	Invention
36	ammonium hexafluorosilicate	cathodic electrolysis	100	-	5	5	Invention
37	ammonium hexafluorotitanate	simple dipping	40	island-like	3	3	Invention
38	ammonium hexafluorotitanate	simple dipping	50	island-like	3.3	6	Invention
39	ammonium hexafluorotitanate	simple dipping	60	island-like, cracks	3.6	6	Invention
40	ammonium hexafluorotitanate	simple dipping	70	island-like, cracks	4	6	Invention
41	ammonium hexafluorotitanate	simple dipping	80	cracks	4.3	6	Invention
42	ammonium hexafluorotitanate	simple dipping	90	cracks	4.6	6	Invention
43	ammonium hexafluorotitanate	simple dipping	100	-	5	5	Invention
44	ammonium hexafluorotitanate	cathodic electrolysis	100	-	5	5	Invention
45	ammonium hexafluorotitanate	simple dipping	100	-	5	5	Invention
46	ammonium hexafluorozirconate	cathodic electrolysis	100	-	5	5	Invention
47	Mixed Solution A	simple dipping	100	-	5	5	Invention
48	Mixed Solution A	cathodic electrolysis	40	island-like	3	3	Invention
49	Mixed Solution A	cathodic electrolysis	50	island-like	3.3	5	Invention
50	Mixed Solution A	cathodic electrolysis	60	island-like, cracks	3.6	5	Invention
51	Mixed Solution A	cathodic electrolysis	70	island-like, cracks	4	6	Invention
52	Mixed Solution A	cathodic electrolysis	80	cracks	4.3	6	Invention
53	Mixed Solution A	cathodic electrolysis	90	cracks	4.6	5	Invention
54	Mixed Solution A	cathodic electrolysis	100	-	5	5	Invention
55	Mixed Solution B	simple dipping	100	-	5	5	Invention
56	Mixed Solution B	cathodic electrolysis	100	-	5	5	Invention
57	Mixed Solution C	simple dipping	100	-	5	5	Invention
58	Mixed Solution C	cathodic electrolysis	100	-	5	5	Invention
59	Mixed Solution D	simple dipping	100	-	5	5	Invention
60	Mixed Solution D	cathodic electrolysis	100	-	5	5	Invention
61	Si	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
62	Si	sputtering	100	-	5	5	Invention
63	Ti	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
64	Ti	sputtering	100	-	5	5	Invention
65	Zr	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
66	Zr	sputtering	100	-	5	5	Invention
67	chromate treating agent	sputtering	-	-	-	5	Comparative
68	untreated	coating	-	-	-	1	Comparative

1) The film was formed by sputtering and then polished with a diamond paste.

Table 3: Examples of substrate metal sheets of aluminum alloy (7001 (Al-Zn-Mg))

No.	Treating Solution (liquid phase process) or Target (sputtering process)	Treating Method	Coverage, %	State of Coat	Film Thickness, μm	Adhesion	Remarks
69	ammonium hexafluorosilicate	simple dipping	100	-	5	5	Invention
70	ammonium hexafluorosilicate	cathodic electrolysis	100	-	5	5	Invention
71	ammonium hexafluorotitanate	simple dipping	40	island-like	3	3	Invention
72	ammonium hexafluorotitanate	simple dipping	50	island-like	3.3	6	Invention
73	ammonium hexafluorotitanate	simple dipping	60	island-like, cracks	3.6	6	Invention
74	ammonium hexafluorotitanate	simple dipping	70	island-like, cracks	4	6	Invention
75	ammonium hexafluorotitanate	simple dipping	80	cracks	4.3	6	Invention
76	ammonium hexafluorotitanate	simple dipping	90	cracks	4.6	6	Invention
77	ammonium hexafluorotitanate	simple dipping	100	-	5	5	Invention
78	ammonium hexafluorotitanate	cathodic electrolysis	100	-	5	5	Invention
79	ammonium hexafluorotitanate	simple dipping	100	-	5	5	Invention
80	ammonium hexafluorozirconate	cathodic electrolysis	100	-	5	5	Invention
81	Mixed Solution A	simple dipping	100	-	5	5	Invention
82	Mixed Solution A	cathodic electrolysis	40	island-like	3	3	Invention
83	Mixed Solution A	cathodic electrolysis	50	island-like	3.3	5	Invention
84	Mixed Solution A	cathodic electrolysis	60	island-like, cracks	3.6	5	Invention
85	Mixed Solution A	cathodic electrolysis	70	island-like, cracks	4	6	Invention
86	Mixed Solution A	cathodic electrolysis	80	cracks	4.3	6	Invention
87	Mixed Solution A	cathodic electrolysis	90	cracks	4.6	5	Invention
88	Mixed Solution A	cathodic electrolysis	100	-	5	5	Invention
89	Mixed Solution B	simple dipping	100	-	5	5	Invention
90	Mixed Solution B	cathodic electrolysis	100	-	5	5	Invention
91	Mixed Solution C	simple dipping	100	-	5	5	Invention
92	Mixed Solution C	cathodic electrolysis	100	-	5	5	Invention
93	Mixed Solution D	simple dipping	100	-	5	5	Invention
94	Mixed Solution D	cathodic electrolysis	100	-	5	5	Invention
95	Si	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
96	Si	sputtering	100	-	5	5	Invention
97	Ti	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
98	Ti	sputtering	100	-	5	5	Invention
99	Zr	sputtering→polishing ¹⁾	80	cracks	4.3	6	Invention
100	Zr	sputtering	100	-	5	5	Invention
101	chromate treating agent	coating	-	-	-	5	Comparative
102	untreated	-	-	-	-	1	Comparative

1) The film was formed by sputtering and then polished with a diamond paste.

In all cases, the precoated metal sheet of the present invention exhibits excellent adhesion as compared with untreated metal sheet and is verified to have an adhesion performance comparable to that of the chromate-treated sheet. Furthermore, the precoated metal sheet of the present invention contains no hexavalent chromium and, accordingly, apparently has little affect on environment as compared with the chromate treated sheet.